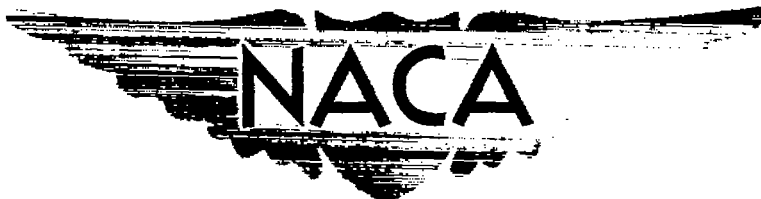


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RESEARCH MEMORANDUM

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ANALYSIS OF V-g RECORDS FROM THE GRUMMAN F8F-2 AIRPLANE

By James O. Thornton

Langley Aeronautical Laboratory
Langley Field, Va.

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RESEARCH MEMORANDUM

ANALYSIS OF V-g RECORDS FROM THE GRUMMAN F8F-2 AIRPLANE

By James O. Thornton

SUMMARY

V-g records obtained in training and operational flights of the F8F-2 airplane are analyzed statistically to show the frequency with which large values of normal load factor and airspeed are encountered. A comparison is made with previous V-g results from the F8F-1 airplane.

INTRODUCTION

V-g recorders have been used for several years as a means of recording the maximum maneuver loads that are encountered by military airplanes in flight. Analysis of these records provides a continuing check of the loads imposed on present airplanes, and the results are useful in predicting the load experience of future airplanes.

V-g records supplied to the NACA by the Bureau of Aeronautics included records from the F8F-1 airplane which were analyzed and reported in reference 1. In the present paper, which supplements reference 1, V-g records obtained from F8F-2 airplanes in 1949 are analyzed statistically to determine the frequency of experiencing large values of normal load factor and airspeed. These results are compared with the results from the F8F-1 airplane.

SYMBOLS

n_{\max}	maximum positive or negative load factor on V-g record, g units
V_0	indicated airspeed at which maximum positive or negative load factor on V-g record is experienced, knots
\bar{n}, \bar{V}_0	average value of the frequency distribution of n_{\max} and V_0 , respectively

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σ	standard deviation of frequency distribution (reference 2)
α_3	coefficient of skewness of frequency distribution (reference 2)
α_4	coefficient of kurtosis of frequency distribution (reference 2)
V_{\max}	maximum indicated airspeed on V-g record, knots
T	average flight time per record, hours

SCOPE OF DATA

The data available for analysis consisted of 43 V-g records representing 1220 hours of flying of F8F-2 airplanes. The distribution of flight hours on these records is shown as a histogram in figure 1 where the flying time per record is plotted against the number of records. The average flying time per record was about 28 hours.

The F8F-2 airplane is a single-place, carrier-based fighter whose average weight at take-off and normal gross weight are about 10,200 pounds. Operations included field carrier-landing practice, rocket and bombing exercises from 7000 feet, high-altitude gunnery with tow at 15,000 feet, and carrier operations during "Operation MIKI."

METHODS AND RESULTS

The V-g instrument is better equipped by its nature to show the growth of V-g envelopes than it is to show the frequency of individual load factors or airspeeds. It is difficult, for instance, to determine the true frequency of a value unless the records are changed so often that the maximum values in each maneuver can be read. Records are not changed this often in practice, and the maximums occurring in milder maneuvers tend to become covered up by those occurring in the more severe maneuvers until finally only the larger maximum values are outstanding on a given record. A count of these maximums can be made to show the growth of the V-g envelope and to indicate approximately the frequency of occurrence of large values of either airspeed or load factor. Such a count would not give the frequency of smaller values. Table I was obtained by counting maximums and shows the frequency with which maximum values of load factor and airspeed were observed to occur on the 43 V-g records taken from F8F-2 airplanes.

Since the data of table I would not give a smooth curve, an appropriate Pearson-type frequency-distribution curve was chosen to fit the data. This curve was fitted by requiring that the first four moments of the data about the mean value match the corresponding moments of the Pearson curve. The matching parameters involved are also shown in table I for each distribution. The use of this procedure assumes that the data are random and are not affected by limitations such as maximum lift coefficient and buffeting boundaries. The method outlined here was used in analyzing the data and is given in more detail in reference 1.

Results are shown in figures 2 to 5. Figures 2 to 4 are Pearson curves transformed by multiplying the inverse of the curve by τ , the average flying time per record, to obtain the number of hours in which, on the average, maximum values on a V-g record will be exceeded. Extrapolated portions of these curves show the trend of the data up to the ultimate load factor or restricted airspeed.

In figure 3 the frequency of positive load factors is compared for the F8F-1 and F8F-2 airplanes. Here the average time in which ultimate load factor is exceeded is used as a criterion of service life, because ultimate load carries an implication of failure. The values of limit load factors and of restricted airspeed shown in the figures were obtained from page 73 of reference 3. Ticks at the right of figure 3 show the average number of hours in which 1 in a group of 10 or 100 F8F-2 airplanes may exceed the positive ultimate load factor. The bottom tick, for example, indicates that in an operating group of 100 F8F-2 airplanes, each of which has flown 100 hours, one airplane might be expected to have exceeded ultimate load. For comparison, all load factors for the F8F-2 are based on a normal gross weight of 10,200 pounds.

The ordinates of figures 2 to 4 may also be considered as the sum of the flying time of a group of airplanes in which, on the average, one airplane may be expected to exceed the given value of load factor or airspeed once.

Figure 5 gives "flight" envelopes of the maximum load factors and airspeeds that may be expected to occur on the average in a given period of time. In this figure the predicted envelopes are compared with a 1220-hour composite of V-g data from the F8F-2 airplane, and with the dashed-line placard envelope of current flight restrictions.

DISCUSSION AND CONCLUDING REMARKS

The data in figure 4 indicate that on the average and under the operations sampled, F8F-2 airplanes will not exceed their restricted speed in over 10^5 flight hours. Reference 1 indicates, however, that

the F8F-1 airplane will usually exceed its restricted speed in 300 hours. This increase in the flight hours to exceed the restricted speed for the F8F-2 airplane may be due to operations that require more extensive use of external auxiliary fuel tanks, which would impose an airspeed restriction on the airplane.

Figures 2 and 5 indicate that the chance that the F8F-2 airplane will reach its negative limit load factor during the life of the aircraft is negligible. Results for the F8F-1 airplane of reference 1 were similar.

Figure 3 indicates that, for the present type of operations and based on the present number of records, the F8F-2 airplane would exceed the ultimate load factor in 10^4 hours of flying. This frequency is approximately ten times as great as that for the F8F-1 airplane. However, owing to the limited data available for the F8F-2 airplane, the difference may not be statistically significant.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

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2. Kenney, John F.: Mathematics of Statistics. Pt. I, pp. 60-75, and Pt. II, pp. 49-51. D. Van Nostrand Co., Inc., 1939.
3. Anon.: Pilot's Handbook for Navy Models F8F-1, F8F-1B, F8F-1N, F8F-2, F8F-2N, F8F-2P Aircraft. AN 01-85FD-1, U. S. Air Force and Bur. Aero., Dec. 1, 1949.

TABLE I

FREQUENCY DISTRIBUTIONS AND PARAMETER VALUES FROM THE F8F-2 AIRPLANE

Load factors above 1g				Load factors below 1g			
n_{max} (g)	Frequency	V_o (knots)	Frequency	n_{max} (g)	Frequency	V_o (knots)	Frequency
2.6 - 2.9	1	150 - 161	1	0.7	1	114 - 125	1
3.0 - 3.3	1	162 - 173	0	0.6	0	126 - 137	0
3.4 - 3.7	1	174 - 185	1	0.5	1	138 - 149	1
3.8 - 4.1	2	186 - 197	0	0.4	2	150 - 161	3
4.2 - 4.5	3	198 - 209	1	0.3	3	162 - 173	1
4.6 - 4.9	4	210 - 221	2	0.2	2	174 - 185	0
5.0 - 5.3	4	222 - 233	2	0.1	0	186 - 197	6
5.4 - 5.7	10	234 - 245	0	0	2	198 - 209	8
5.8 - 6.1	9	246 - 257	2	-0.1	6	210 - 221	5
6.2 - 6.5	4	258 - 269	2	-0.2	10	222 - 233	3
6.6 - 6.9	1	270 - 281	9	-0.3	4	234 - 245	3
7.0 - 7.3	1	282 - 293	8	-0.4	2	246 - 257	1
7.4 - 7.7	0	294 - 305	3	-0.5	1	258 - 269	1
7.8 - 8.1	0	306 - 317	0	-0.6	1	270 - 281	3
8.2 - 8.5	1	318 - 329	1	-0.7	3	282 - 293	3
8.6 - 8.9	1	330 - 341	6	-0.8	0	294 - 305	2
		342 - 353	3	-0.9	1	306 - 317	1
		354 - 365	0	-1.0	1	318 - 329	0
		366 - 377	1	-1.1	2	330 - 341	1
		378 - 389	0	-1.2	1		
		390 - 401	1				
$\bar{n} = 5.5$ $\sigma = 1.14$ $\alpha_3 = 0.25$ $\alpha_4 = 4.26$		$\bar{V}_o = 285.6$ $\sigma = 49.1$ $\alpha_3 = -0.32$ $\alpha_4 = 3.27$		$\bar{n} = -0.2$ $\sigma = 0.43$ $\alpha_3 = 0.31$ $\alpha_4 = 2.92$		$\bar{V}_o = 223.3$ $\sigma = 48.0$ $\alpha_3 = 0.27$ $\alpha_4 = 2.62$	

TABLE I - Concluded
 FREQUENCY DISTRIBUTIONS AND PARAMETER VALUES FROM
 F8F-2 AIRPLANE

Maximum Indicated Airspeed	
V_{\max} (knots)	Frequency
300 - 304	1
305 - 309	0
310 - 314	2
315 - 319	0
320 - 324	0
325 - 329	0
330 - 334	2
335 - 339	2
340 - 344	2
345 - 349	3
350 - 354	5
355 - 359	1
360 - 364	2
365 - 369	4
370 - 374	1
375 - 379	5
380 - 384	1
385 - 389	2
390 - 394	2
395 - 399	2
400 - 404	5
405 - 409	0
410 - 414	1
$\bar{V}_{\max} = 365.4$ $\sigma = 26.8$ $\alpha_3 = -0.31$ $\alpha_4 = 2.46$	



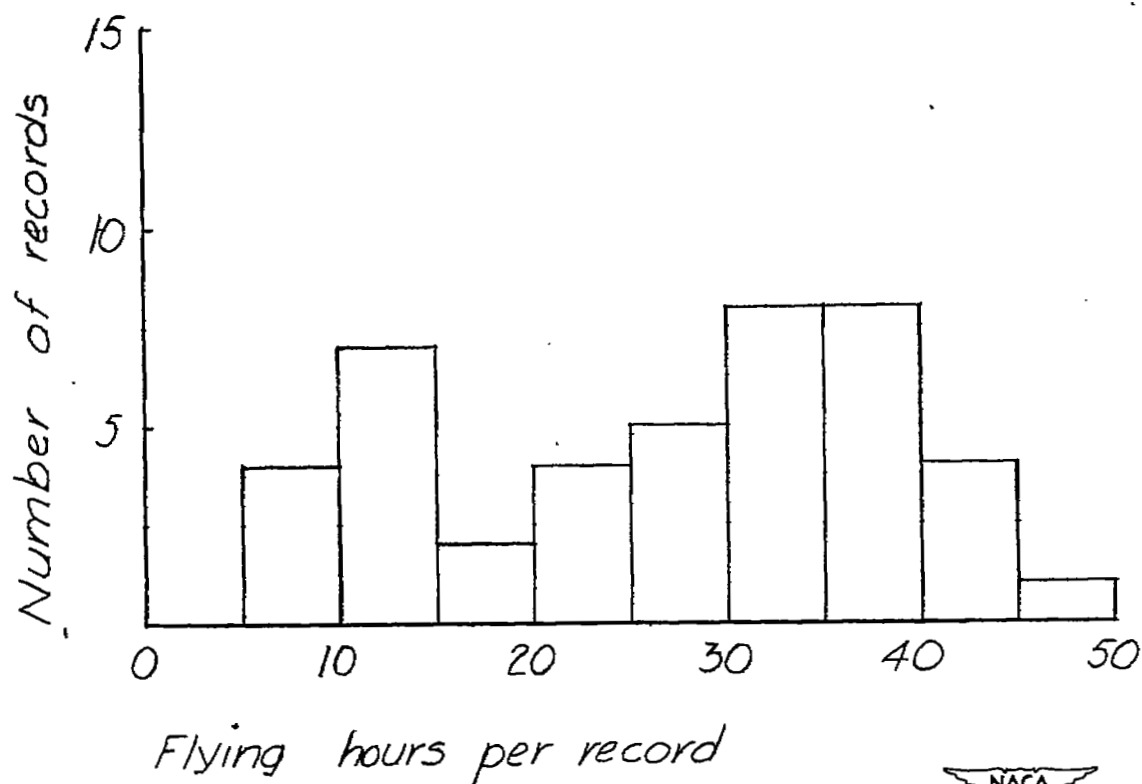


Figure 1.- Distribution of flying hours on 43 V-g records from the F8F-2 airplane. $\tau = 28.4$ hours.

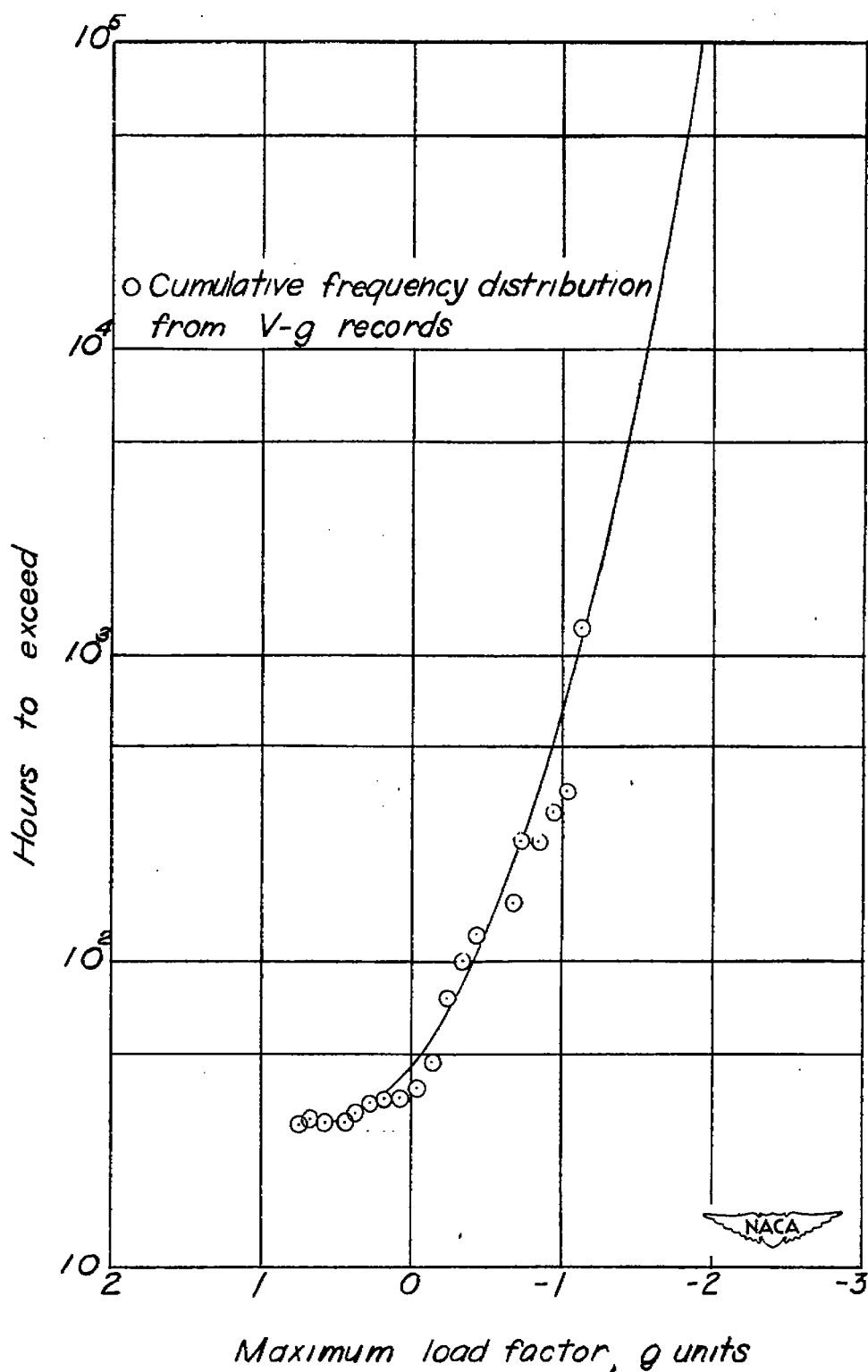


Figure 2.- Average time required to exceed given values of maximum negative load factor on a V-g record.

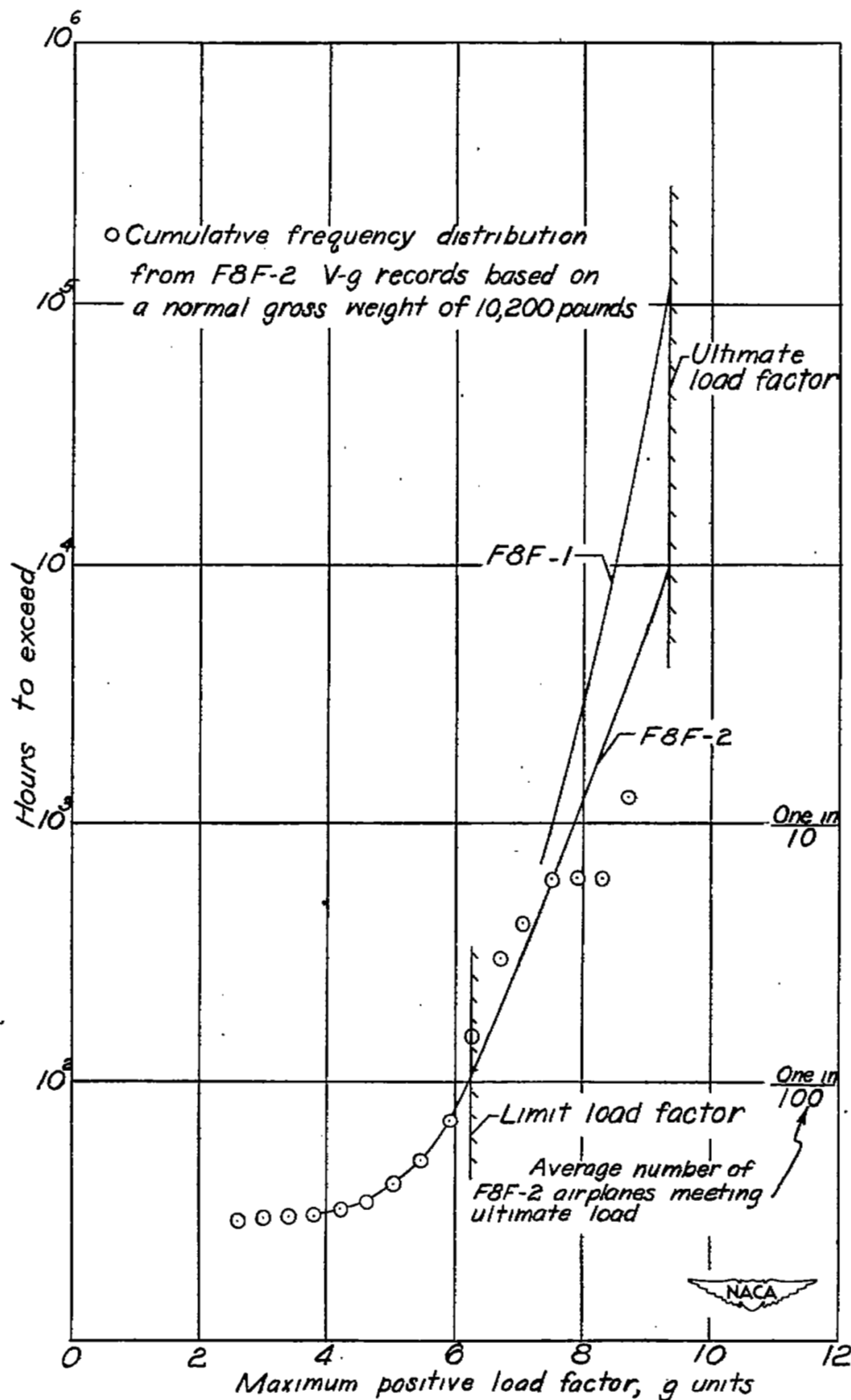


Figure 3.--A comparison of the average time required to exceed given values of maximum load factor on V-g records from F8F-1 and F8F-2 airplanes.

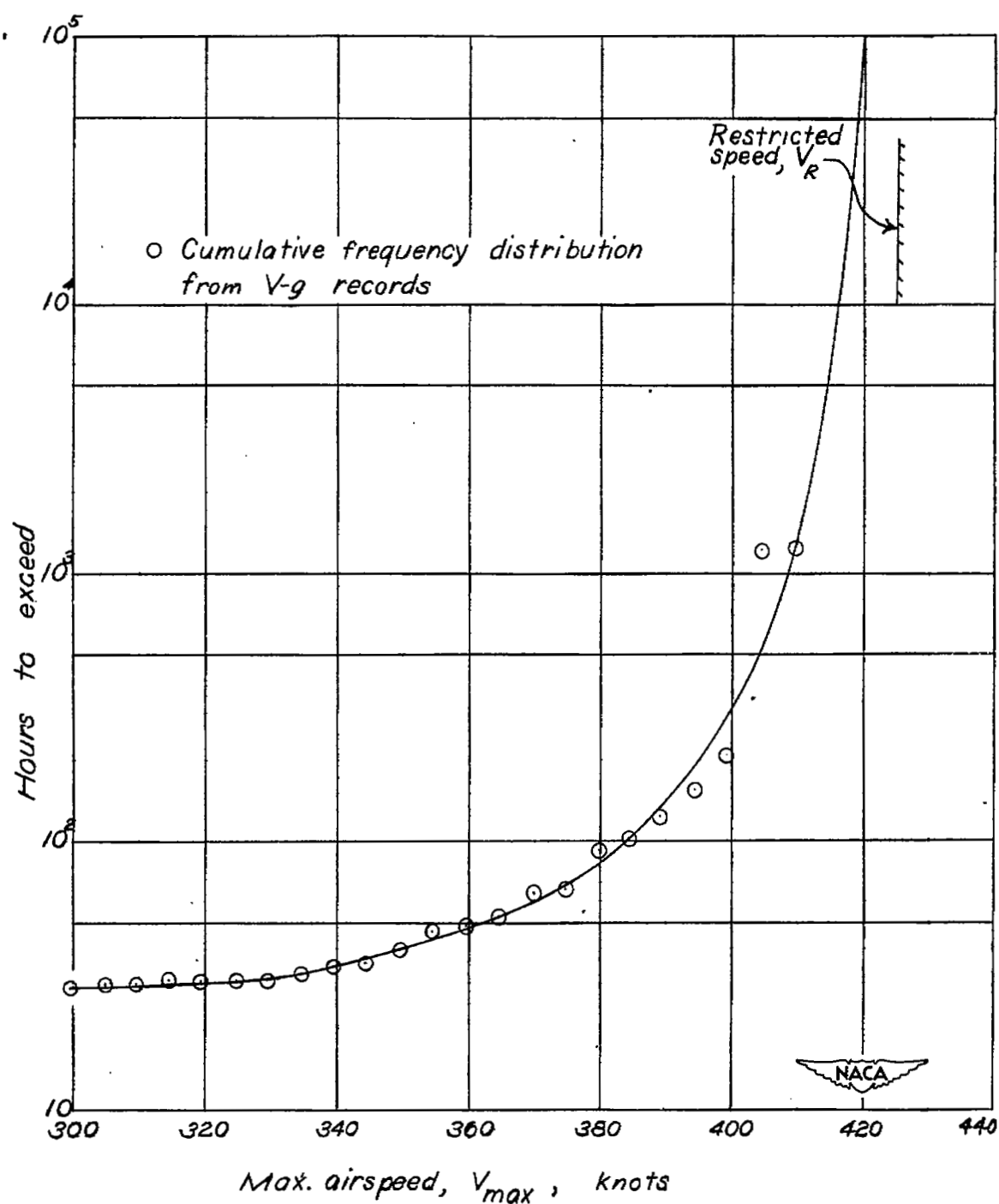


Figure 4.- Average time required to exceed given values of maximum airspeed on a V-g record.

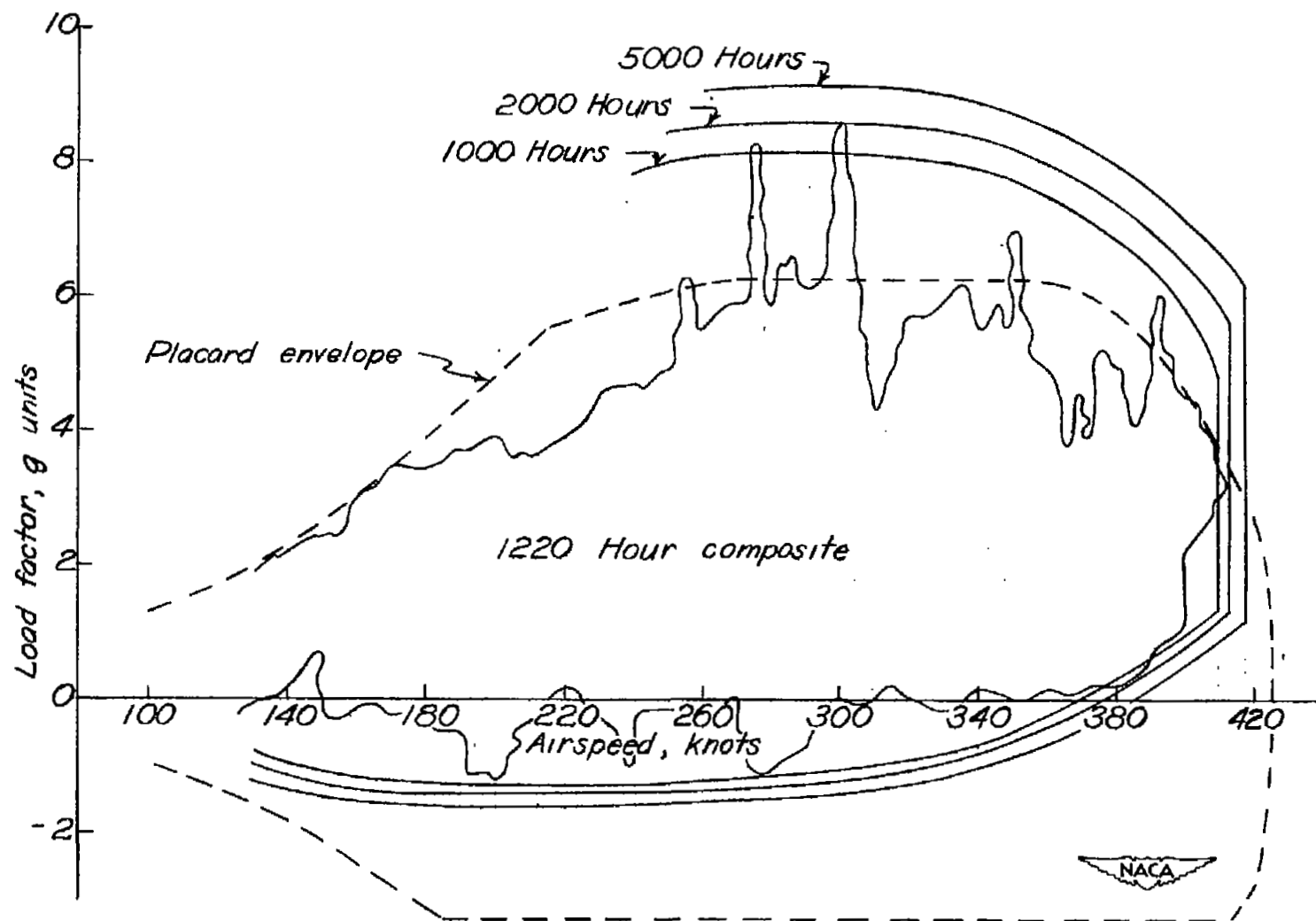


Figure 5.- Comparison of 1000-, 2000-, and 5000-hour flight envelopes for the F8F-2 airplane and the actual 1220-hour composite.

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